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Advanced Life Support and Human Performance

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National Aeronautics and Space Administration

STMD Strategic Framework – ALSHP Contributions

LEAD	THRUSTS	OUTCOMES	CAPABILITIES
Ensuring American global leadership in Space Technology • **Lunar Exploration building to Mars and new discoveries at extreme locations** • **Robust national space technology engine to meet national needs** • **U.S. economic growth for space industry** • **Expanded commercial enterprise in space**	**Go** *Rapid, Safe, & Efficient Space Transportation*	• Enable Human Earth-to-Mars Round Trip mission durations less than 750 days. • Enable rapid, low cost delivery of robotic payloads to Moon, Mars and beyond. • Enable reusable, safe launch and in-space propulsion systems that reduce launch and operational costs/complexity and leverage potential destination based ISRU for propellants.	• Advanced Propulsion • Cryogenic Fluid Management
	Land *Expanded Access to Diverse Surface Destinations*	• Enable Lunar and Mars Global Access with ~20t payloads to support human missions. • Land Payloads within 50 meters accuracy while also avoiding local landing hazards.	• Human & Robotic Entry, Descent and Landing • Precision Landing
	Live *Sustainable Living and Working Farther from Earth*	• **Conduct Human**/Robotic **Lunar Surface Missions in excess of 28 days without resupply.** • **Conduct Human Mars Missions in excess of 800 days including transit without resupply.** • Provide greater than 75% of propellant and **water/air consumables from local resources for Lunar and Mars missions.** • Enable Surface habitats that utilize **local construction** resources. • **Enable Intelligent robotic systems augmenting operations during crewed and un-crewed mission segments**.	• **Advanced life support and human performance** • Advanced Materials, Structures and **Manufacturing** • Advanced Power Systems • In-situ Propellant and **Consumable Production** • Autonomous Systems and Robotics
	Explore *Transformative Missions and Discoveries*	• Enable new discoveries at the Moon, Mars and other extreme locations. • Enable new architectures that are more rapid, affordable, or capable than previously achievable. • Enable new approaches for in-space servicing, assembly and **manufacturing**. • Enable next generation space data processing with higher performance computing, communications and navigation in harsh deep space environments.	• On-orbit Servicing, Assembly and Manufacturing • Small Spacecraft Technologies • Advanced Avionics • Advanced Communications & Navigation

Note: Multiple Capabilities are cross cutting and support multiple Thrusts. Primary emphasis is shown

Colored Text Legend
- **Directly ALSHP**
- **Related to ALSHP**

ALSHP Capabilities

- Capabilities that keep our astronauts healthy and productive while living and working in space
- Broadly divided between vehicle systems (ECLSS) and crew health capabilities (CHP)
- Scope does not include thermal or EVA but SCLT does coordinate with SMEs

ENVIRONMENTAL CONTROL & LIFE SUPPORT SYSTEMS (ECLSS)

- Life Support
- Environmental Monitoring
- Fire Safety
- Logistics

CREW HEALTH & PERFORMANCE (CHP) SYSTEMS

- EVA Physiology
- Radiation
- Countermeasures
- Food and Nutrition
- Exploration Medical

ALSHP Decomposition Examples - ECLSS

FUTURE Deep Space

TODAY International Space Station

CAPABILITY AREAS

LIFE SUPPORT
- Atmosphere Management
- Water Management
- Waste Management

SOA KPPs:
- Heavy reliance on spares and maintenance
- 47% O_2 Recovery from CO_2
- 90% H_2O Recovery

Gaps

Goal KPPs (few examples):
- Reduced spares through reliability and maintainability
- >75% O_2 Recovery from CO_2
- 98% H_2O recovery

ENVIRONMENTAL MONITORING
- Pressure O_2 & N_2
- Moisture
- Particles
- Microbes
- Chemicals
- Sound

Today:
- Reliance on sample returns to Earth for analysis
- Limited, crew-intensive on-board capability

Future:
- Identify and quantify species and organisms in air & water
- On-board analysis capability with no sample return

FIRE SAFETY
- Detection
- Protection
- Suppression
- Cleanup

Today:
- Only depress/repress clean-Up
- Obsolete combustion product sensor
- 2-cartridge mask
- Large CO_2 suppressant tanks

Future:
- Smoke eater
- Exploration combustion product monitor
- Simple cartridge mask
- Water mist portable fire extinguisher

LOGISTICS
- Tracking
- Clothing
- Packaging
- Trash

Today:
- Bag and discard
- Disposable cotton clothing
- Packaging disposed
- Manual scans, Displaced items

Future:
- Resource recovery before disposal
- Long-wear Clothing/laundry
- Bags/foam repurposed with additive manufacturing
- Automatic, autonomous RFID

- State Of the Art (SOA) best representative operational performance (may be on ISS or ground)
- Key Performance Parameters (KPPs) are major characteristics (e.g. mass, volume, power, specific/normalized performance measures)

ALSHP Decomposition Examples - CHP

FUTURE Deep Space

TODAY International Space Station

CAPABILITY AREAS

EVA Physiology

- Crew Required Capabilities
- Suit Design
- Physiological Inputs and Outputs
- ConOps
- Informatics
- Injury & Risk Mitigation
- Exploration Atmosphere/Prebreathe

Today:

- Current Suits
- ISS EVA Lessons Learned on Crew Performance
- Injury Risk due to Sub-Optimal Suit Fit
- ISS Prebreathe from Normal Atmosphere

Future:

- Improved Suits Utilizing Learnings about Crew Health, Performance, Cognitive Performance, and Injury Risk
- Improved Crew Performance during EVA Operations
- Mitigation of Injury Risk in Exploration EVAs
- Mitigate Decompression Sickness with Exploration Atmosphere

Countermeasures

- Exercise Equipment
- Exercise Performance
- Physiology Monitoring

Today:

- Current Large ISS Exercise Equipment
- Exercise Performance Standards in Development
- Pre- and Post-Flight Biometric Monitoring

Future:

- Smaller Exploration Exercise Equipment
- Sensorimotor, Strength, and Aerobic Fitness Standards for Exploration
- Pre- and In-Flight Biometric Monitoring with Feedback
- In-Flight Physical Performance Assessment Tools

Radiation

- Models & Forecasting
- Monitoring
- Shielding

Today:

- GCR Models, Vehicle Models
- Limited Radiation Shielding Needed at ISS

Future:

- Improved GCR Models and Vehicle Models
- Active Shielding, GCR Thick Shielding
- Storm Shelter Materials (Integration with Vehicles)

Exploration Medical

- Diagnostic
- Treatment

Today:

- ISS Medical Kit
- Research on Conditions and Treatment Plans Underway

Future:

- Condition List and Treatment Plan Complete
- More Capable Exploration Medical System

Food & Nutrition

- Pre-packaged Food
- Food Storage
- Bioregenerative Food
- Dietary Tracking
- Food Processing

Today:

- Nutritional Shelf Life < 3 Years
- Food Fatigue is Resolved with Variety via Resupply
- No Cold Stowage for Food

Future:

- Nutritional Shelf Life > 3 Years
- Reduce Mass of Food
- Innovation to Reduce Food Fatigue and Supplement Nutrition
- Cold Stowage for Food

Communicating a Technology's Potential

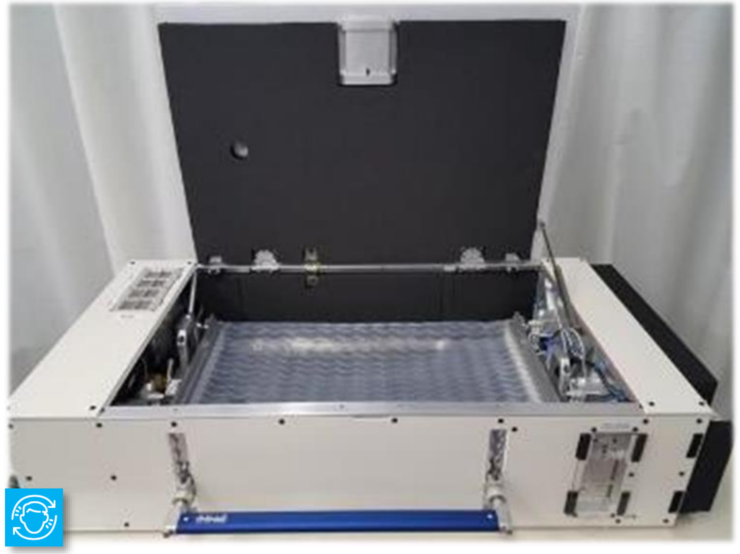
- **ALSHP heavily uses systems analysis and mission trade studies to inform technology selections**
- **Qualitative descriptions are helpful but are insufficient by themselves**
- **KPPs have the power of quantitatively conveying an advantage over the SOA**
  - Providing and explaining estimated KPPs allows NASA to readily relate potential ideas to NASA mission needs
- **Sources of SOA and KPP information**
  - SBIR topic call descriptions and associated references
  - STMD's strategic technology plans (to be released)
  - Public conferences, a few examples (not endorsements):
    - AIAA ASCEND
    - Human Research Program Investigators' Workshop
    - International Aeronautical Congress / Committee on Space Research (COSPAR)
    - International Space Station Research and Development Conference
    - Space Travel Adaptive Research and Technologies from Biological and Chemical Engineering

KPP Type	KPP Title	Units Description
Mass / Power / Volume	Specific Mass	kg hardware-hr/kgCO2
	Specific Power	W hardware-hr/kgCO2
	Mass of wipes supplied	wet wipes mass per crewmember-day (kg/CM-day)
	Down-Mass	kg returned/month mission duration
Dormancy	Dormancy Recovery Resupply	% System Mass replaced to recover from dormancy
Storage/Resupply	Consumables (to include calibration fluids) over mission duration	m^3 Consumables/m^3 hardware
Performance	ppCO2	1 hr average
	O2 recovery	% of O2 recycled from CO2
	Medical O2 purity	Percent O2
	Localization Accuracy (Instrumented Module)	RMS error for 80% of tagged population (cm)
	Percent of ECLSS Maintenance Tasks Achieved Autonomously	% (Autonomous Tasks/Total ECLSS Tasks) × 100 %)
	Mass collected particulates/mass filtration hardware	g particulates/kg hardware
	Nutritional stability	Years to maintain 100% nutrition, safety, and acceptability
	Countermeasure meets CHP standards for aerobic fitness, muscle strength, bone health, and sensorimotor	Percentage of CHP standards met (egress, 0g EVA, lunar EVA, Martian EVA)
	Vibration isolation of exercise for the vehicle	Percent of modeled exercise data that meets standard for vehicle load
Reliability/ Maintainability	Results of analysis	Minimum percentage of false positive/negative
	Maintainability	Downtime for maintenance (Hrs)

Examples

Examples of ALSHP Hardware and Systems

4-Bed CO_2 Scrubber



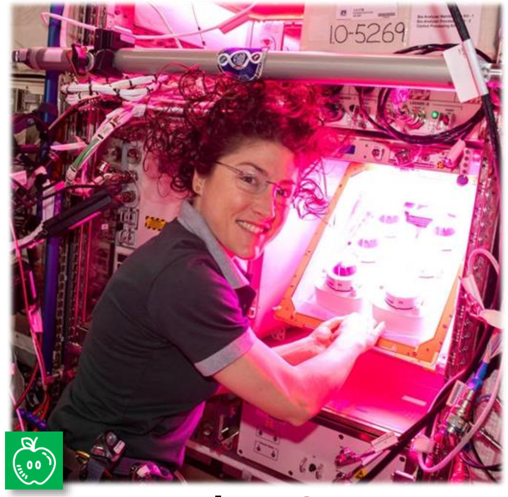
Urine Brine Processor Assembly

Combustion Product Monitor

Airborne Particle Monitor

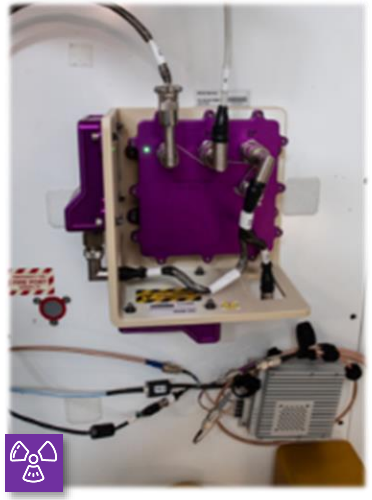
Trash Processing

Exercise & Vibration Isolation



Veggie-PONDs

Validating EVA Inspired CO_2



Radiation Monitoring

0g & CO_2 Diagnostics

ALSHP Strategic Goals

- **Reduced mass of loop closure**
  - Specific compound/species identification environmental monitoring (air/water/particulate/microbial) without sample return
  - Improved IVA atmospheric CO_2 removal/O_2 recovery(>75% recovery)
  - Consumables/high usage spares that can be additively manufactured
  - In-space trash mass reduction and jettison technologies
  - IVA soft goods for high oxygen flammability resistance
  - Venting/disposal strategies for planetary protection
  - Improved air/water sorbent/IX capacities
- **Increased reliability to reduce spares mass**
  - Autonomous diagnostics and care taking of ALSHP systems during non-crewed periods
  - Improved microbial control of potable water, equipment, and IVA surfaces
  - Lunar dust removal and tolerance
- **Maintain crew performance for duration of mission to support EVAs and reentry**
  - In flight medical diagnostics/treatment hardware adaptations for space
  - Informatics for IVA countermeasure and EVA effectiveness
  - Improved acoustic noise prevention and mitigation
  - Exercise equipment vibration isolation
  - In-situ food production and sanitizing